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624A SOLID-PROPELLANT MOTOR IMPACT TEST

by

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ABSTRACT. At the request of the Air Force Systems Command, a preprototype version of the 624A motor, with a single center segment plus end closures, was impacted into a massive concrete, steel, and earth target at a velocity of 667 fps to determine the hazard potential of the motor. Photographic data showed extensive grain breakup from the impact, and blast-gage data indicated a low range of overpressure and impulse forces. Fragments of motor case were thrown to 2,500 ft, and pieces of burning propellant were thrown to 3,000 ft.

This report presents a description of the test setup, procedures, results, and conclusions.

U.S. NAVAL ORDNANCE TEST STATION

China Lake, California

October 1964

U. S. NAVAL ORDNANCE TEST STATION

AN ACTIVITY OF THE BUREAU OF NAVAL WEAPONS

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FOREWORD

On 13 June 1964, a preprototype, heavy case, static firing version of the 624A solid-propellant motor was impacted against a concrete, steel, and earth target at a velocity of 667 fps off the muzzle of the Supersonic Naval Ordnance Research Track (SNORT). The test was conducted to aid in evaluating the potential hazard of the motor when used as the booster of a Titan III C missile.

This report, which has been reviewed and approved by the Space Systems Division, presents a description of the test setup, procedures, results, and conclusions.

The work was funded by the Space Systems Division of the Air Force Systems Command on MIPR No. SS-64-SSD-12 (Local Project No. 886).

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INTRODUCTION

This report documents a test conducted on the Supersonic Naval Ordnance Research Track (SNORT), at the request of the Space Systems Division of the Air Force Systems Command, to obtain information relating to the hazard potential of the 624A solid-propellant motor. (Two multisegment 624A motors are to be used as the zero stage of the Titan III C vehicle.)

The test item, a preprototype, heavy case, static firing version of the 624A motor equipped with a single center segment, was impacted at a velocity of 667 fps into a concrete, steel, and earth target placed 100 ft from the muzzle end of the track. The test approximated a fall-back condition from an altitude in excess of 10,000 ft with impact on a hard surface.

Test setup, procedures, results, and conclusions are described below.

TEST SETUP

Test Item

The motor tested was manufactured by the United Technology Center, Sunnyvale, California. It differed from flight hardware in that it had a heavier motor case, was equipped with only one cylindrical center segment instead of five, and was, therefore, considerably shorter than the actual stage-zero motor complex of Titan III C. The test motor was 120 in. in diameter, approximately 16 ft long (without the nozzle), and had a 3/4-in. steel case. It had a forward and an aft closure, both of which had skirts that allowed the sled rings to be bolted to the test item; an igniter and igniter adapter; a nozzle having a 6-deg upward cant; and one cylindrical segment. Component weights were as follows:

Loaded cylindrical segment	77,805 lb
Loaded forward closure	23,860
Loaded aft closure	23,211
Igniter adapter	160
Igniter (RP-3)	122
Nozzle	3,202
Miscellaneous motor hardware	150
Total motor weight	128,510 lb
Total propellant weight (before firing)	92,543
Approximate propellant weight at impact	82,000

Test Vehicle

The test sled consisted of two rings, four trucks (two forward and two aft), and 14 isolation skids--three for each forward truck and four for each aft truck. The rings were designed to bolt to the skirts of the forward and aft closures of the motor during motor assembly. Since the motor had to be assembled in the vertical position, the rings were designed with trunions to accommodate the cranes used to hold the motor while it was being rotated to the horizontal position and placed on the track.

The trucks were the links between the rings and the isolation skids that fit on the rail heads. The skids were isolated from the trucks by rubber in the pin connection to reduce the track-induced vibration experienced by the motor during the run. The trucks and the skids were placed on the track, and the motor (bolted to the rings) was lowered onto them.

Target Configuration

The target face was constructed of reinforced concrete 6 ft in depth with a 20 x 20-ft impact surface. The concrete face was backed with 3-in. steel plate and this, in turn, was backed with approximately 35 ft of earth fill, 20 ft high. The concrete was prefabricated in blocks and placed in position 100 ft off the muzzle end of the track. The target impact surface had openings to accept the sled trucks to insure that the test item experienced initial contact. Figure 1 is a view of the target before the test.*

*Figures 1-23 appear at the end of the report beginning on page 12.

Instrumentation

Instrumentation included overpressure gages, seismographs, geophones, cameras, and radio-link telemetry. Because of the many unknown factors in this test, the choice of instrumentation was somewhat arbitrary in some areas. It was chosen in an effort to obtain optimum coverage by using a combination of suggestions from all groups concerned.

Overpressure Gages. Overpressure was measured with Kistler piezoelectric and Ballistics Research Laboratory (BRL) gages. The Kistler gages use remotely controlled Ampex FR100 tape recorders to collect data; the BRL gages have a self-contained recording device. The pressure is sensed on a diaphragm that is attached to a stylus. The stylus scribes the diaphragm movements on an aluminum-coated glass disc. The disc is rotated by a chronometrically governed DC drive motor. Diaphragms rated to measure anticipated overpressures were placed in the gages. Figure 2 shows a typical gage installation. Both types of gages were mounted to get side-on, pressure-time data. The Kistler transducer was mounted at the top of the horizontal section of tubing shown in the photograph. The BRL gages were mounted flush with the ground surface.

Locations of pressure sensors are shown in Fig. 3; Table 1 lists types of Kistler gages and the nominal pressure ranges of the BRL instruments used at the various gage positions. The Air Force Rocket Propulsion Laboratory, Edwards AFB, California, provided consulting services for the gage layout and provided the Kistler gages. (Table 1 is repeated on page 13 for reader convenience.)

TABLE 1. Overpressure Gages

Position (ft)	Leg #1 (North)	Leg #2 (West)	Leg #3 (Southeast)
A 91		Kistler - 601A BRL - 100 psi	BRL - 50 psi
B 154		Kistler - 601A BRL - 50 psi BRL - 25 psi	BRL - 25 psi
C 266		Kistler - 601A BRL - 15 psi BRL - 5 psi	Kistler - 601A BRL - 15 psi BRL - 5 psi
D 512	BRL - 5 psi	Kistler - 701A BRL - 5 psi BRL - 1 psi	Kistler - 601A BRL - 1 psi
E 1,130	BRL - 1 psi	BRL - 1 psi	Kistler - 701A BRL - 0.5 psi
F 1,900	BRL - 0.5 psi		BRL - 0.5 psi

Seismograph and Geophone Installations. Personnel of the Division of Seismology, Coast and Geodetic Survey, Department of Commerce, instrumented the NOTS range area with seismographs and geophones to gather seismic data from the test. These data have been documented.*

Range Photography. The four major range camera functions were (1) surveillance of the motor during the run, (2) surveillance of the motor at impact, (3) gathering of velocity data from track muzzle to target impact, and (4) gathering of data on fireball growth.

Table 2 lists camera types, positions, lens sizes, frame rates, types of film, fields of view, and information to be recorded. Figure 4 is a camera layout sketch in which the camera numbers correspond to those listed in Table 2. NOTE: N, E, and W figures denote distances in feet from a common point at breech end of track. N = northerly along track, E and W = east or west of track centerline. This note applies throughout the entire report.

Telemetry. A six-channel FM/FM telemetry package was mounted in the forward left-hand truck of the test vehicle to gather motor environmental data during the run. One purpose of recording TM data was to be able to determine the cause of malfunction in case of a gross failure of the motor during the run. The functions monitored included vertical and lateral vibration on the forward and aft rings, linear acceleration, and combustion chamber pressure.

TEST PROCEDURES

Preliminary Preparations

First, an assembly area was constructed at track station 17,700 ft north (4,000 ft from the target face) and the necessary roadwork was done. Then, the week before the test motor arrived at NOTS, the target was assembled and overpressure instrumentation preparation was started. The motor was delivered to the range four days before the test and motor assembly was started the next day.

Motor Assembly

The motor was transported in three major units--the forward closure with igniter installed, the cylindrical segment, and the aft closure with nozzle installed. The motor was assembled in the vertical, nozzle-up position and rotated to the horizontal position with two 90-ton cranes, then placed on the sled trucks. Assembly and rotation took two days. Figure 5 shows the aft sled ring being put in position; Fig. 6 shows the motor being rotated to the horizontal position.

*"Seismic Disturbances Generated by Titan III 624A Solid Motor Test," by W. V. Mickey and T. R. Shugart, October 1964.

TABLE 2. Hazard Evaluation Camera Instrumentation

Camera numbers and locations correspond to the layout shown in Fig. 4.

Camera number and type	Location	Lens	Rate (pps)	Film	Field of view	Remarks
1. Fastax 16 WF-3	17,000'N x 30'E	6"	2,000	Color	Near pt. 17,650'N 30' vert x 1,800' hor	Monitor ignition 500' travel
2. Milliken 16mm	19,300'N x 30'E	6"	400	Color	Far pt. 17,700'N Near pt. 18,900'N 60' vert x 1,200' hor	Monitor 1,200' travel
3. Milliken 16mm	20,300'N x 30'E	6"	400	Color	Far pt. 18,400'N Near pt. 19,600'N 60' vert x 1,200' hor	Monitor 1,200' travel
4. Photo-Sonics 10B	21,500'N x 1,100'E	7"	360	Color	21,400'N - 21,700'N	Monitor 200' travel, free flight, impact
5. Fastax 16 WF-4	21,700'N x 1,100'E	9"	6,000	Color	30' vert x 52' hor	Medium shot of item on target face
6. Fastax 16 WF-3	21,700'N x 1,100'E	15"	2,000	Color	17' vert x 31' hor	Closeup of item on target face
7. Fastax 16 WF-4	21,700'N x 1,100'E	4"	4,000	ECOCR	66' vert x 125' hor	Fireball
8. Milliken 16mm	21,700'N x 1,100'E	10mm	400	Color	19,600'N - 20,600'N	Travel from 19,600'N to 20,600'N
9. Milliken 16mm	21,700'N x 100'E	10mm	400	Color	20,600'N - 21,600'N	Travel from 20,600'N to 21,600'N
10. Fastax 16 WF-3	21,690'N x 320'E	6"	4,000	Color	13' vert x 19' hor	Closeup of impact of item on target
11. Fastax 16 WF-3	21,690'N x 320'E	12mm	4,000	Color	150' vert x 220' hor	Fragment distribution
12. Fastax 16 WF-3	21,690'N x 320'W	6"	4,000	Color	13' vert x 19' hor	Closeup of impact of item on target
13. Fastax 16 WF-3	21,690'N x 320'W	12mm	4,000	Color	150' vert x 220' hor	Fragment distribution
14. Fastax 16 WF-4	21,700'N x 1,100'W	9"	6,000	Color	30' vert x 52' hor	Medium shot, item impact
15. Fastax 16 WF-3	21,700'N x 1,100'W	15"	2,000	Color	17' vert x 31' hor	Closeup of item impact
16. Fastax 16 WF-4	21,700'N x 1,100'W	4"	4,000	ECOCR	66' vert x 125' hor	Fireball
17. Photo-Sonics 4B 35mm	21,700'N x 1,100'W	6-1/2"	2,000	Color	21,600'N - target	Velocity in free flight
18. Photo-Sonics 1C 16mm	21,700'N x 1,100'W	3"	1,000	Color	21,550'N - target	Free flight and impact
19. Photo-Sonics 4B 35mm	10,000'N x 3,000'E	75"	500	Color	N-45 tracking	On B-4 road
20. Milliken 16mm	10,000'N x 3,000'E	24"	400	Color	N-45 tracking	On B-4 road
21. Photo-Sonics 10A 70mm	10,000'N x 3,000'E	150"	60	Color	N-45 tracking	On B-4 road
22. Photo-Sonics 1B 16mm	21,680'N x 100'E	1"	1,000	Color	30' vert x 45' hor	Close impact data
23. Photo-Sonics 1B 16mm	21,680'N x 100'W	1"	1,000	Color	30' vert x 45' hor	Close impact data

The day before the test, the telemetry package was installed and checked out; the destruct receiver and decoder were mounted on the motor, and the motor was prepared for firing with the exception of installing the initiator and destruct charges. Instrumentation checkouts were in progress during the week. Figure 7 shows the motor ready to be fired.

Test Firing

The test was fired at 1320 hours on 13 June 1964. The motor performed as predicted for the 4,000-ft run, striking the target at a measured velocity of 667 fps. The 100 ft of motor free-flight from the track muzzle to the target was as ballistic studies had predicted and the sled trucks entered the target access holes so that the motor igniter made first contact with the target. The following atmospheric conditions existed at the time of the test:

Wind	8.5 fps from 180 deg
Temperature	94.5°F
Humidity	13%
Atmospheric pressure	926.3 millibars
Density	0.00204 slugs/ft^3

TEST RESULTS

Photographic Data

Surveillance film shows that the motor penetrated approximately six ft into the target before failures were apparent. The case expanded and cracked at the forward end of the motor in both quadrants on the west side. The cracks propagated to the aft end of the segment as the motor tried to penetrate deeper. The first sign of fire came from the front of the motor after target penetration. After the motor had entered the target to approximately half the motor length, the aft closure ruptured around the nozzle followed by complete destruction of the motor. Figure 8 shows enlarged 16mm film sequence of motor impact. The force of the explosion left a crater approximately seven ft deep where the target had been.

Figure 9 is a series of pictures of the propellant after it was expelled from the motor (burning propellant was thrown as far as 3,000 ft from the impact point). Figure 10 is a sample of the size of the pieces of unburned propellant, most of which was found along the track. The total amount of unburned propellant was quite small. Residue on the ground surface left by the impact of the burning propellant was roughly circular in shape and varied from two inches to ten feet in diameter. The sand was melted and the residue had the appearance of aluminum.

Figure 11 shows typical residue from burned propellant. The forward closure (Fig. 12) was found 270 ft beyond the target site. Figures 13, 14, and 15 show the debris to the east, west, and north of the target location; Fig. 16 shows the nozzle and other debris in the crater; Figure 17 shows the target face from the track muzzle before and after the test. Travel of some fragments was found as shown in Fig. 18. Descriptions of the fragments are keyed to the numbers in the graph. Figure 19 is a montage showing large pieces of debris found between 1,260 and 2,500 ft from point of impact (see note, page 4).

Telemetry Data

The firing pulse was sent from the SNORT programmer at zero time, and all the following events, taken from the TM record, are referenced to that time:

Motor ignition	0+209 ms
Sled first motion	0+443 ms
Time of impact	0+13.307 sec
Thrust-chamber pressure	+550 psi
Average acceleration	1.4g

Data from the four vibration channels were not assessed since they are not pertinent to the evaluation of the test. Sections of the TM record are shown in Fig. 20.

Pressure Gage Data

The chief source of data from the overpressure instrumentation came from the BRL gages. There was a failure of the Kistler gage recorder on leg #2 and no information was recorded by the Kistler gages at that location. The failure could not be reproduced after the test; therefore, the cause is unknown. However, Kistler gages at distances of 512 and 1,130 ft on leg #3 apparently provided valid overpressure data which, in general, agreed with the data obtained from the BRL gages at the same locations. Additionally, all three Kistler gages on leg #3 yielded time of arrival of the shock wave.

Table 3 gives the gage stations, peak overpressures, duration of overpressure wave, and impulses as computed for the BRL gages by the Ballistics Research Laboratory and in the Kistler gages by the U. S Naval Ordnance Test Station. Figure 21 is a graph of the overpressures compared to reference curves for 4,100, 8,200, and 16,400 lb of TNT, as derived from BRL Memorandum Report No. 1518*; Fig. 22 is a plot of impulse measurements using reference curves for the above amounts of TNT, as derived from a scaled impulse versus scaled distance curve prepared by C. Kingery of BRL.**

TABLE 3. Overpressure and Impulse Data

Station	Distance (ft)	Overpressure (psi)	Pulse Duration (ms)	Impulse (psi - ms)
BRL GAGES				
Leg #1 North				
D	512	1.4	70.5	40.2
E	1,130	0.526	81.2	18.2
F	1,500	0.324	86.1	13.5
Leg #2 West				
A	92	24.4	34.1	250.
B	154	11.8	39.9	144.
B	154	11.0	42.5	145.
C	266	4.4	49.2	75.3
C	266	4.2	58.5	93.8
D	512	2.0	68.9	49.8
D	512	No Record	--	--
E	1,130	No Record	--	--
Leg #3 (SE)				
A	91	42.3	41.9	541.
B	154	Poor Record	--	--
C	266	9.0	48.7	150.5
C	266	7.9	50.3	163.5
D	512	2.07	70.1	66.2
E	1,130	0.763	88.2	28.1
F	1,500	0.414	115.9	20.8
KISTLER GAGES				
Leg #2 West	No Record	--	--	--
Leg #3 (SE)				
C	Poor Record	--	--	--
D	512	2.1	47.	47.
E	1,130	0.66	89.	29.

*Ballistics Research Laboratory. "Peak Overpressure Vs. Scaled Distances for TNT Surface Bursts." April 1964. BRL Memorandum Report No. 1518. This report covers measurements made on 5-, 20-, and 100-ton hemispherical charges.

**------. Curve is based on data recorded from 5-, 20-, and 100-ton TNT surface bursts and was transmitted to NOTS by BRL letter, C. N. Kingery/sri/31258, dated 11 September 1964.

The times of arrival of the overpressure wave were taken from the Kistler gage record on the southeast leg. The times are taken from 9 ms after initial impact (as measured by sledborne telemetry) to the leading edge of the overpressure pulse and are as follows:

266 ft from impact - 145 ms

512 ft from impact - 324 ms

1,130 ft from impact - 844 ms

The 9 ms cited above is an approximation accounting for the interval between impact and initial rapid expansion of the fireball.

The average velocities of the pressure wave calculated from the distances and times listed above are as follows:

From target to 266 ft - 1,834 fps

From 266 ft to 512 ft - 1,374 fps

From 512 ft to 1,130 ft - 1,188 fps

CONCLUSIONS

Inspection of individual values for overpressure and impulse shows a tendency for gages close to the target on the southeast leg (#3) to run higher than corresponding gages on the west leg (#2). Gage records from the north leg (#1) ran lower than those from corresponding positions on the west and southeast legs. This is anticipated behavior since gages on the southeast leg near the target were expected to sense overpressure reinforcement resulting from target reflections, and gages on the north leg were sheltered from the full effect of the blast by the target mass.

Table 4 shows values of TNT equivalent yield in pounds and percentages:

TABLE 4. TNT Equivalency Values

Gage Line	Av. yld in lb TNT from peak pressure	Av. % yld from peak pressure	Av. yld in lb TNT from impulse	Av. % yld from impulse
Leg 1 (N)	3,300	4.0	3,700	4.5
Leg 2 (W)	4,900	5.9	4,700	5.7
Leg 3 (SE)	8,800	10.6	9,500	11.6
Average*	5,700	6.9	6,000	7.3
Average**	6,440	7.8	5,800	8.3
Average***	6,100	7.4	5,700	7.0

*Giving equal weight to each leg.

**Giving equal weight to each gage record.

***Omitting all records on leg 1, records at 91 and 266 ft on leg 3, and pressure record at 91 ft, leg 2. Equal weight assigned to each of the remaining gage records.

Yields derived from peak pressure were based on the following formula:

$$W = W_o \left(\frac{\rho_z}{\rho_o} \right) \left[\frac{\text{Actual distance}}{\text{Scaled distance}} \right]^3$$

where

W = yield in lb of TNT

W_o = 1 lb of TNT

ρ_z = ambient air density

ρ_o = air density at 1,013 mb pressure and 59°F

Actual distance = distance from target impact to gage

Scaled distance = scaled distance corresponding to ratio:

$\frac{\text{recorded overpressure}}{\text{ambient pressure}}$ as shown in tabulation in BRL Memo Report #1518

Yields based on impulse data were derived by interpolation between computed TNT weight versus impulse values which, in turn, were derived from the BRL curve used as the source of reference lines on Fig. 22.

In general, the recorded overpressure-time histories were classical in shape; however, a few BRL records exhibited an unusually long rise time to peak pressure. Figure 23 shows typical gage records, four of which are from BRL gages and one is from a Kistler gage. The Kistler gage record at 512 ft on the SE leg was less regular in shape and more difficult to interpret than the record of the Kistler gage at 1,130 ft on the same leg.

Because of inherent limitations, BRL gages at 91 ft on the west and southeast legs had only marginal capability in detecting true peak pressure at this distance from the blast. This may account for the low peak pressure values at 91 ft as contrasted with the trends shown by other gages on the west and southeast legs, and as contrasted with impulse values for the gages at 91 ft.

The relationship between the energy release associated with the propellant reaction at impact and the blast wave is obscured somewhat by other factors, some of which may contribute to the blast wave and some of which detract from it. Two possible contributors are kinetic energy and the rupturing of the motor case as a pressure vessel. The computed kinetic energy contribution combined with the computed rupture action can account for less than 1% of TNT equivalency for the assumed 82,000 lb of propellant at impact. On the other hand, the pro rata division of all available energy into principal effects (i.e., creation of a blast wave, target and motor destruction, and fragment dispersal) is very difficult to determine. It is apparent, however, that energy required for destruction and fragment dispersal is not available for blast wave formations in the atmosphere.

In view of the above, it is considered that the best estimate of TNT equivalency for the test item under the test conditions experienced is 7.5%, plus or minus 2%.

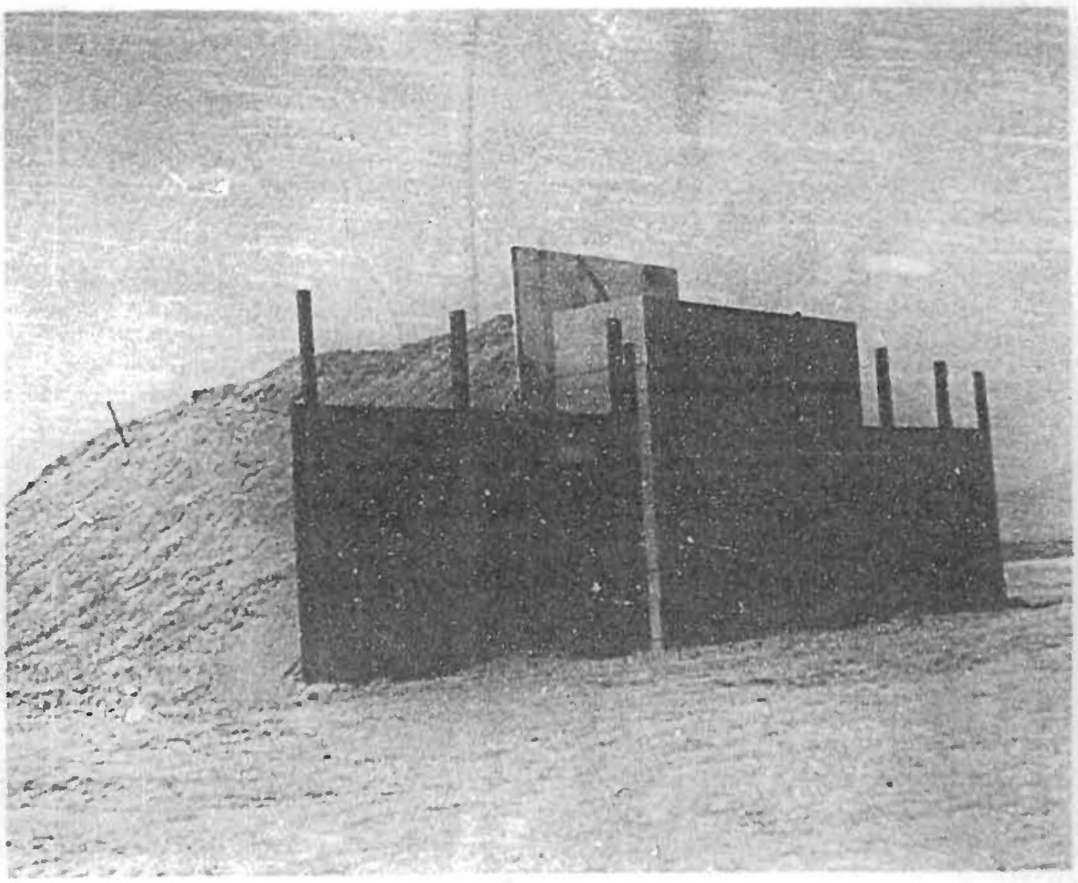

FIG. 1. Target Used in 624A Motor Impact Test.

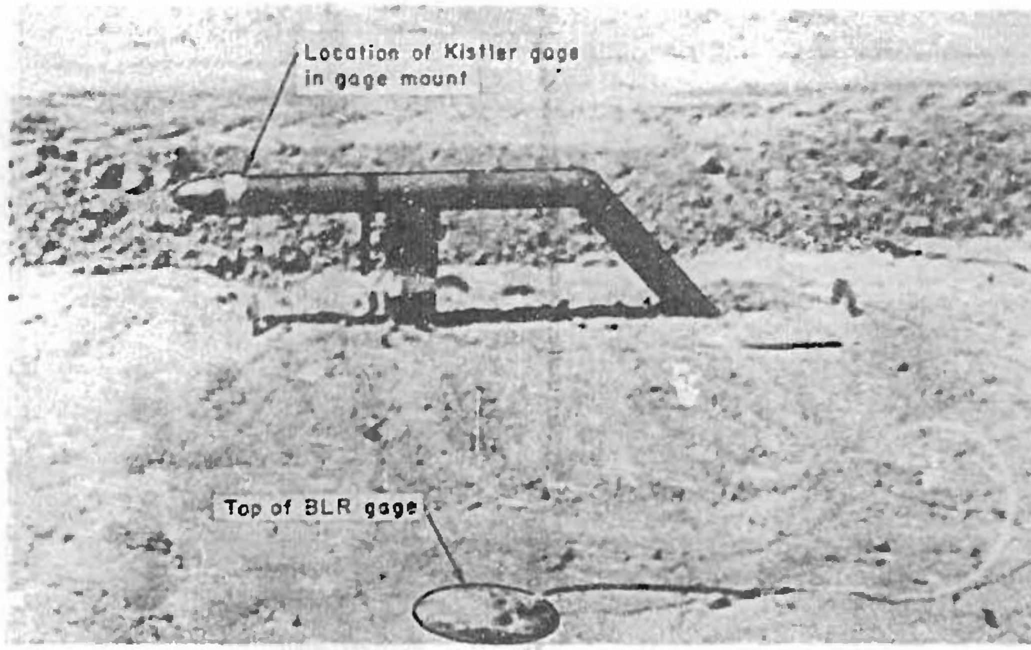

FIG. 2. Enlarged Film Frame Showing Typical Blast Gage Installation.

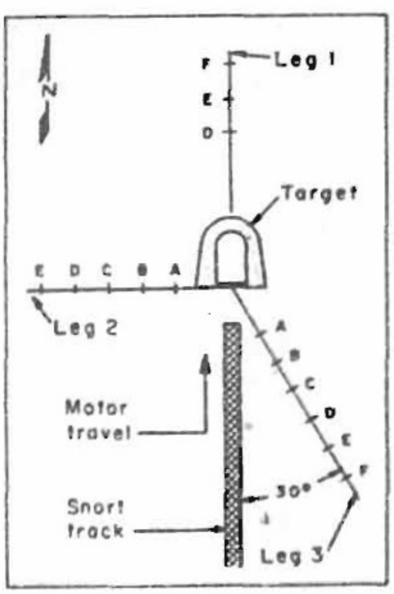

FIG. 3. Pressure Gage Location Chart.

TABLE 1. Overpressure Gages

Position (ft)	Leg #1 (North)	Leg #2 (West)	Leg #3 (Southeast)
A 91		Kistler - 601A BRL - 100 psi	BRL - 50 psi
B 154		Kistler - 601A BRL - 50 psi BRL - 25 psi	BRL - 25 psi
C 266		Kistler - 601A BRL - 15 psi BRL - 5 psi	Kistler - 601A BRL - 15 psi BRL - 5 psi
D 512	BRL - 5 psi	Kistler - 701A BRL - 5 psi BRL - 1 psi	Kistler - 601A BRL - 1 psi
E 1,130	BRL - 1 psi	BRL - 1 psi	Kistler - 701A BRL - 0.5 psi
F 1,900	BRL - 0.5 psi		BRL - 0.5 psi

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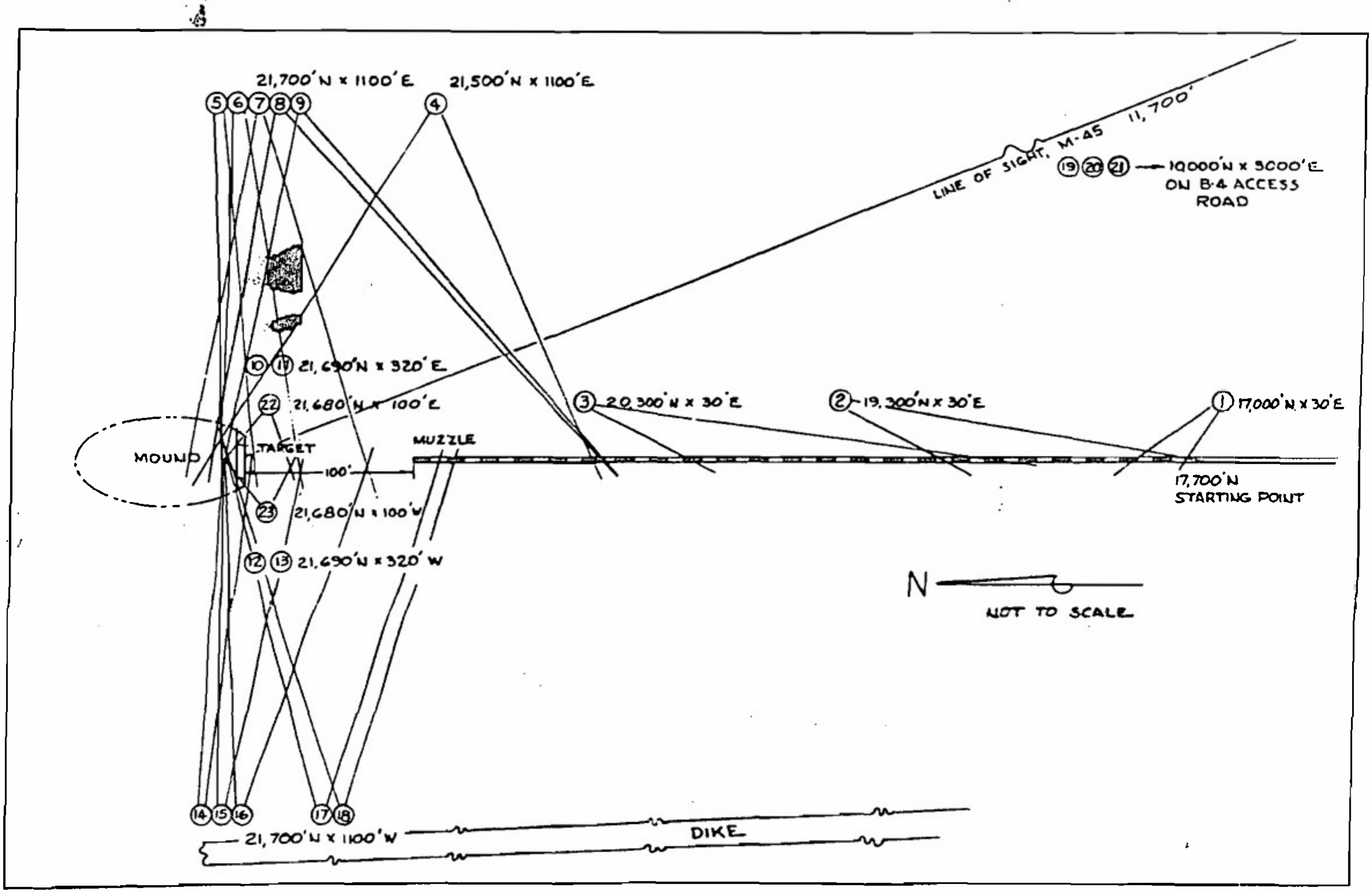

FIG. 4. Camera Layout Used in Hazard Evaluation Test.

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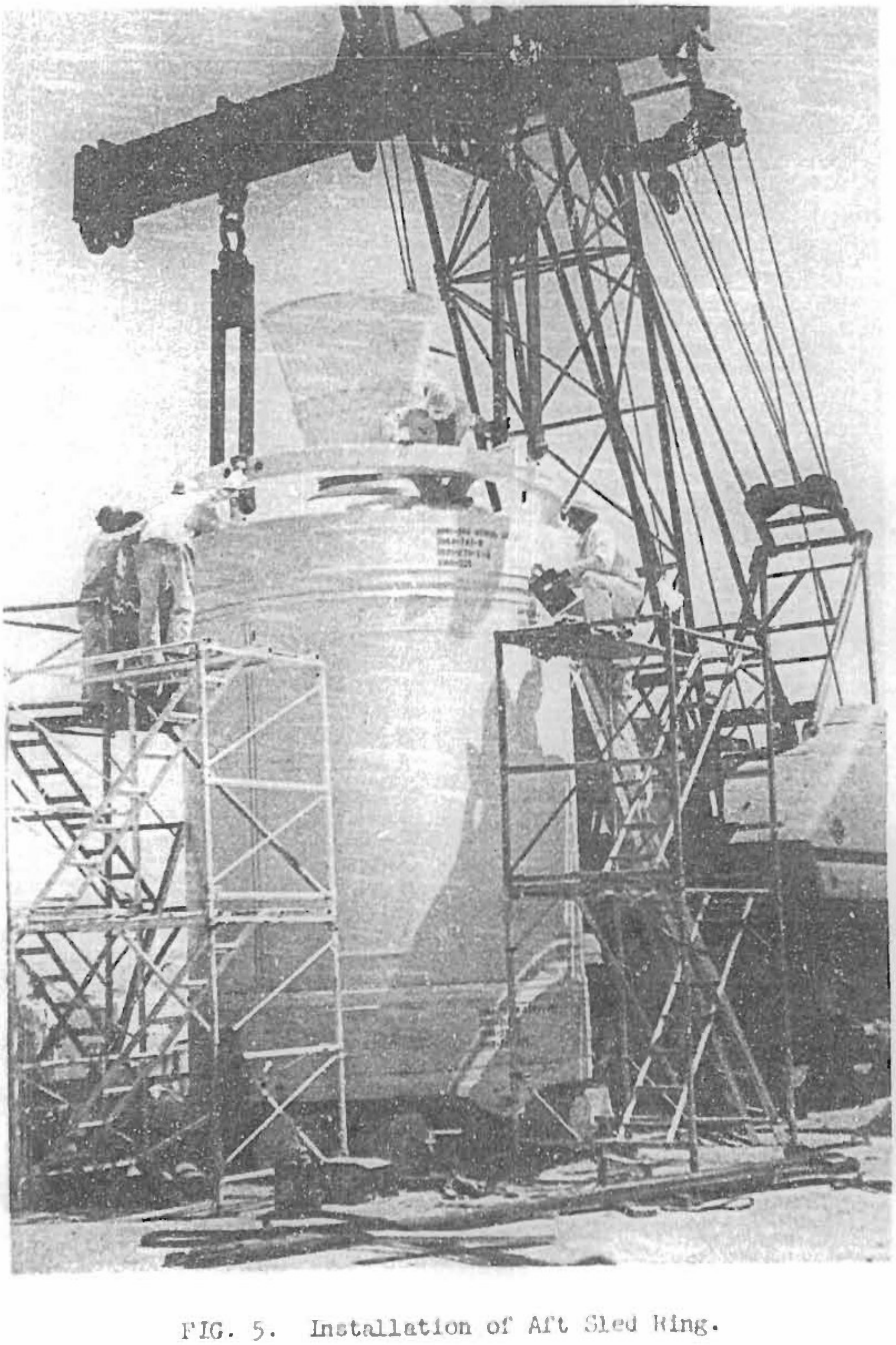


FIG. 5. Installation of Aft Sled Ring.

FIG. 6. Rotation of Test Motor Before Being Mounted on Track.

FIG. 7. Motor Ready for Firing.

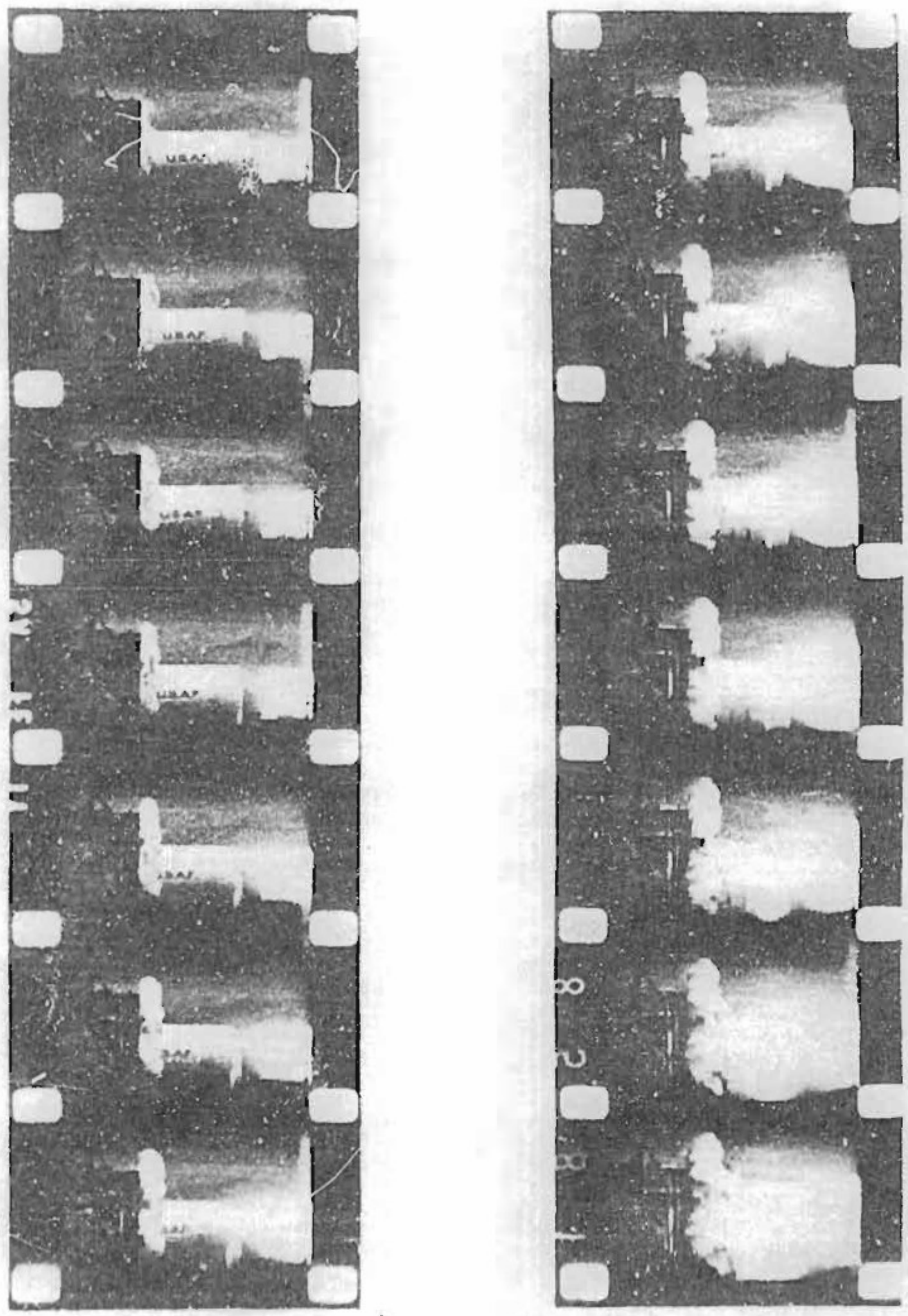


FIG. 8. Enlarged Sequential Film Frames Showing Motor Impact.

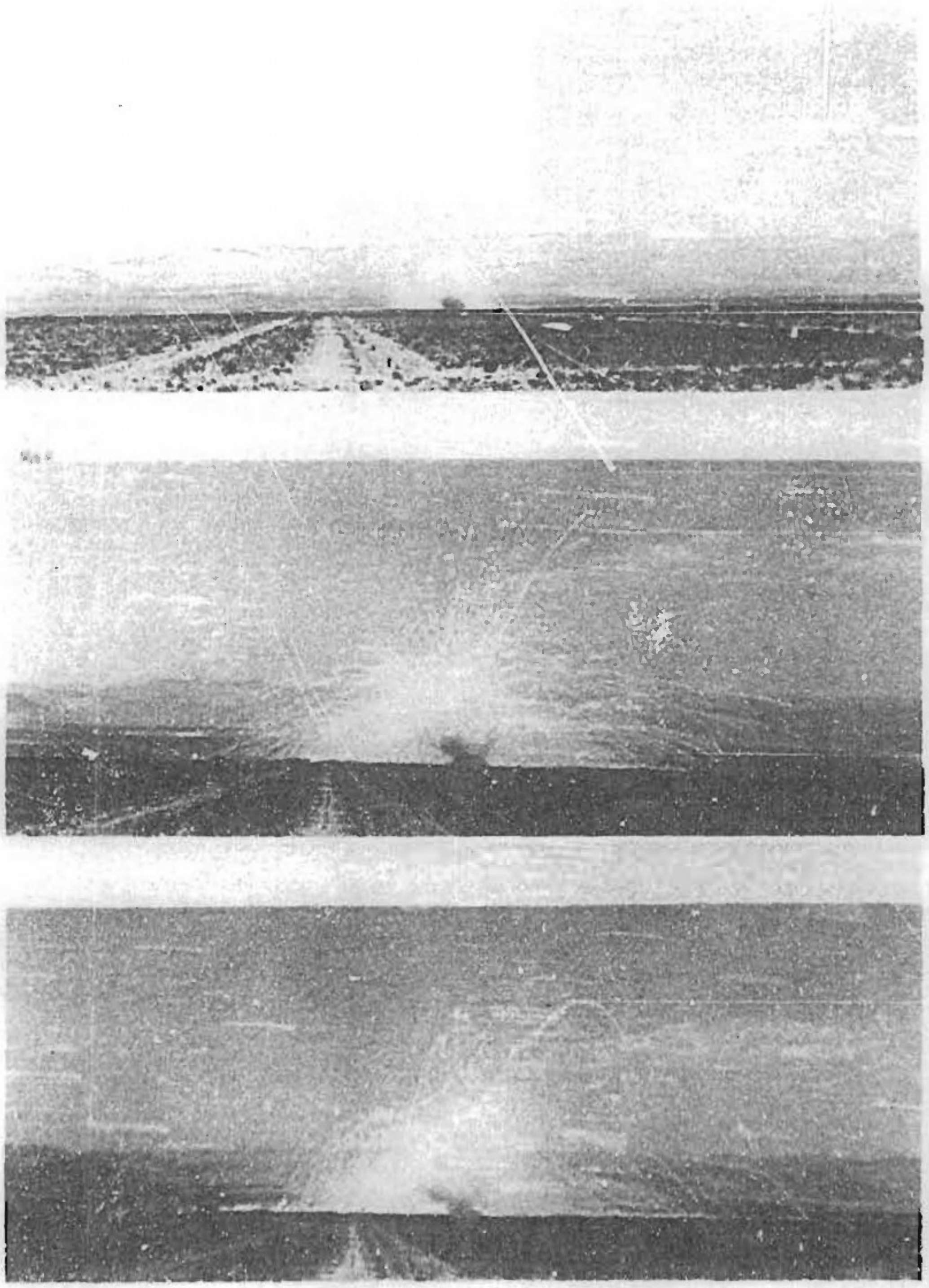


FIG. 9. Photographic Sequence After Motor Impact as Viewed From a Distance of 4.1 Miles. Sequence is from top to bottom.

FIG. 10. Typical Pieces of Unburned Propellant.

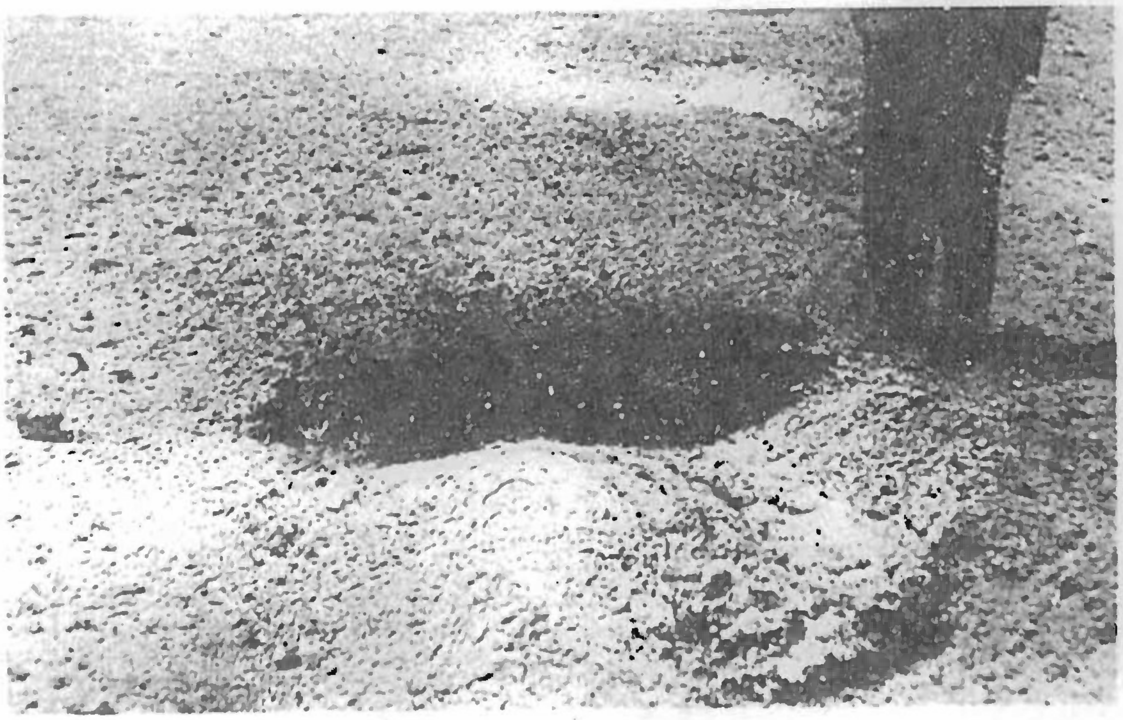


FIG. 11. Typical Residue From Burned Propellant.

FIG. 12. Forward Closure.

FIG. 13. Debris to East of Target.

FIG. 14. Debris to West of Target.

FIG. 15. Debris to North of Target. Arrow points to position of forward closure shown in closeup view, Fig. 12.

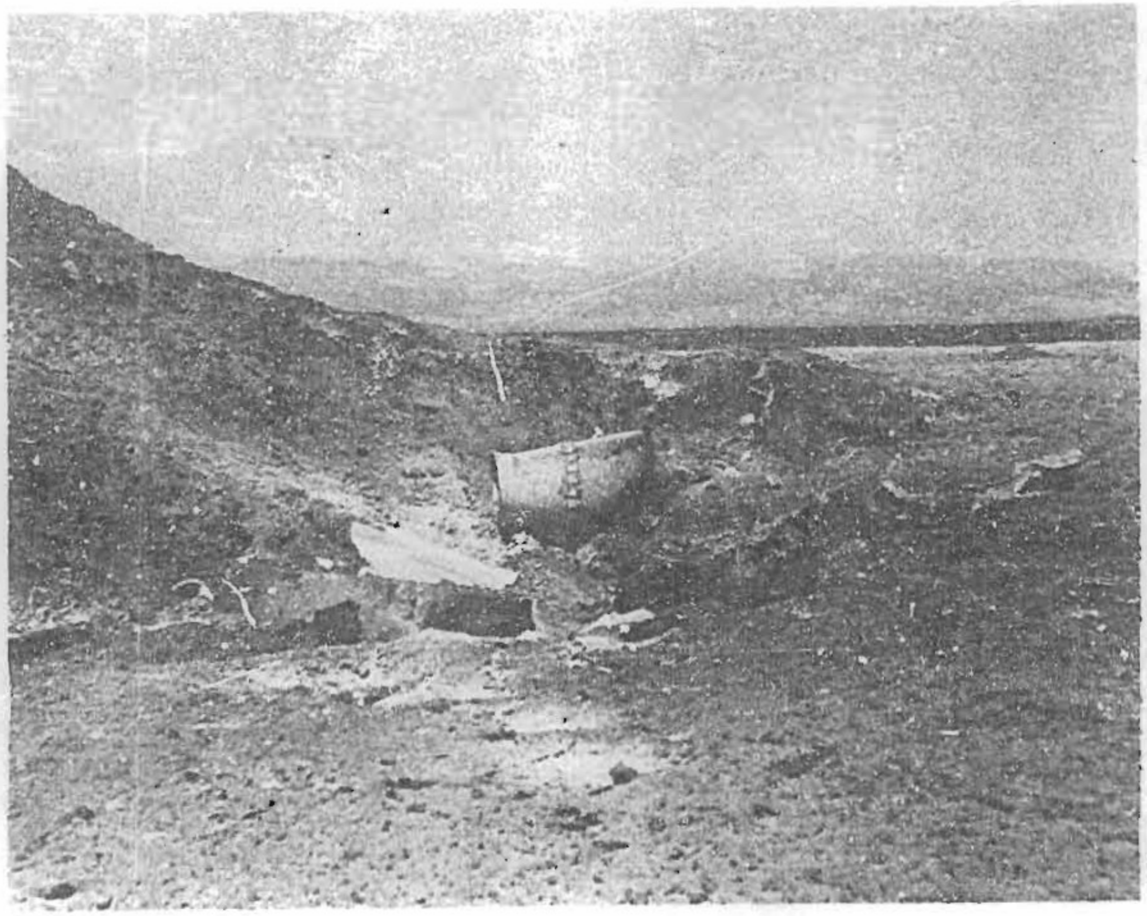


FIG. 16. Debris and Crater at Target Site.

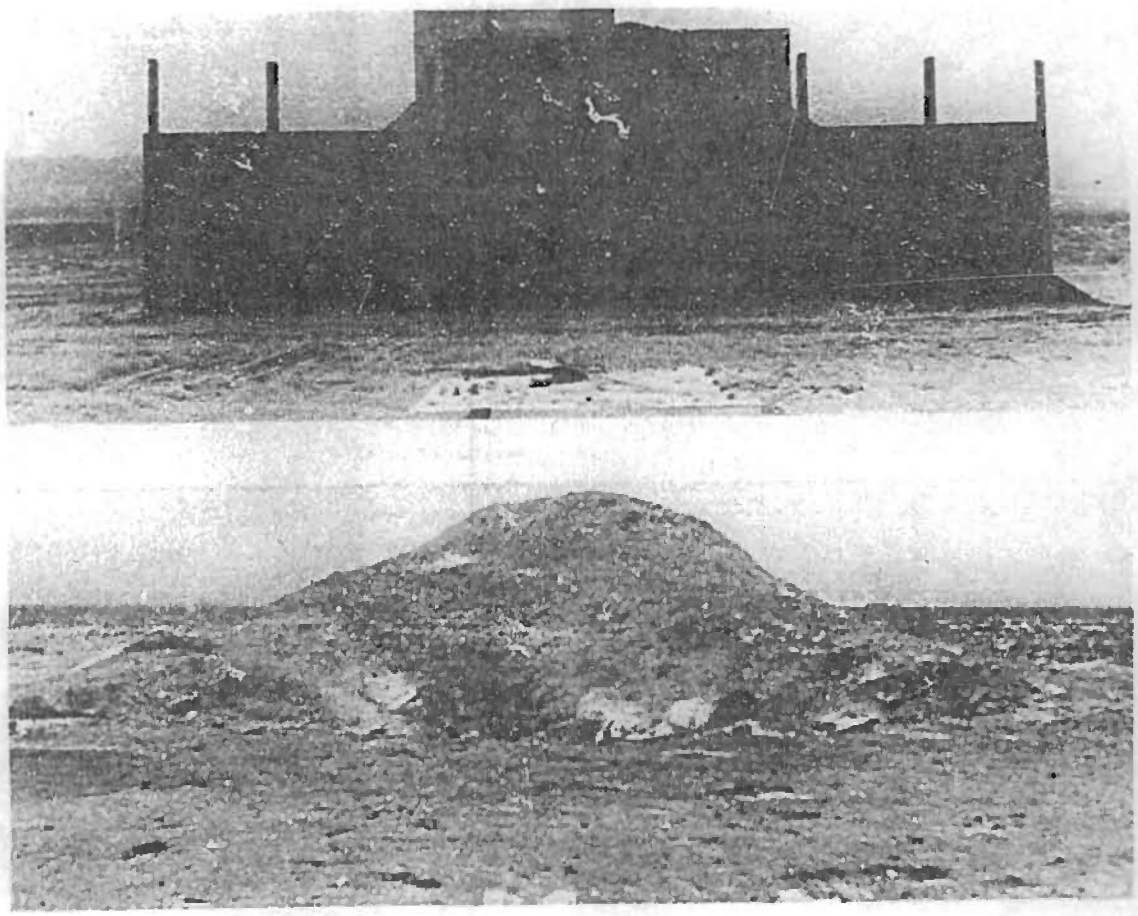
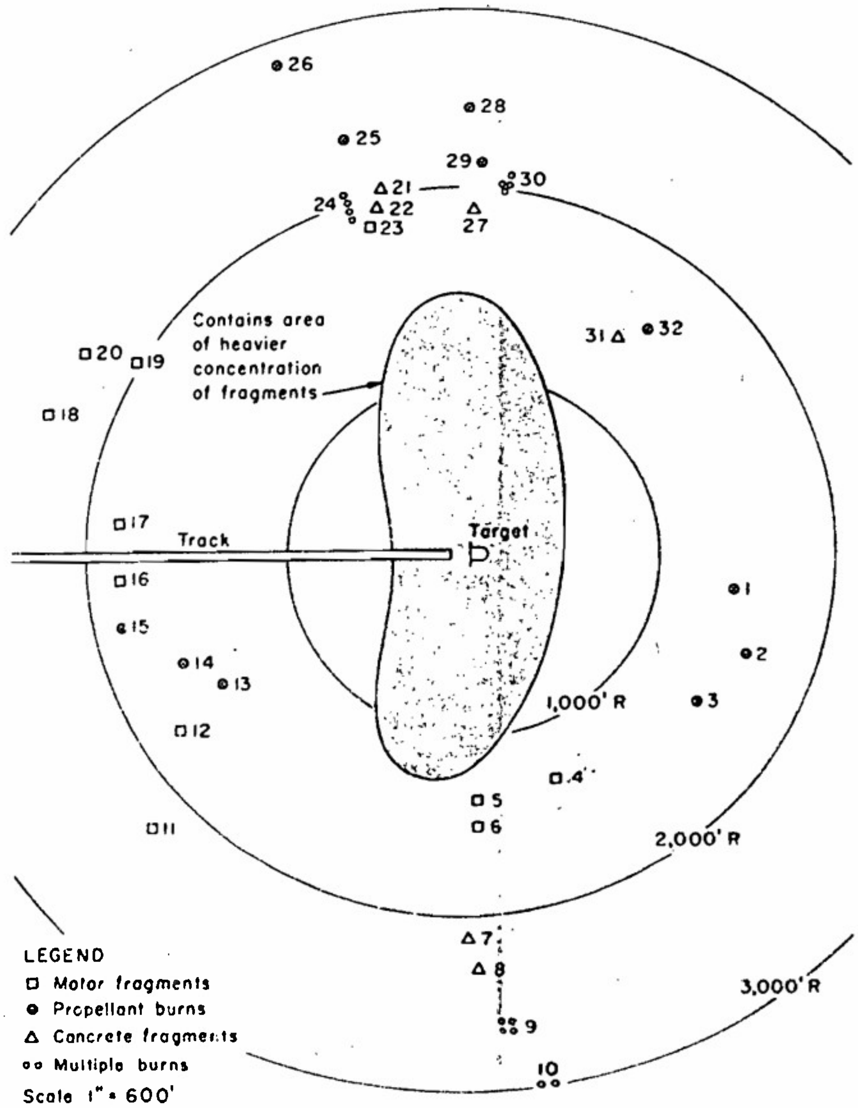


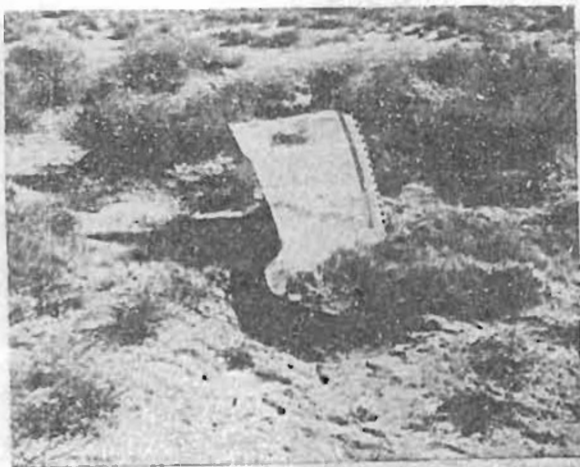
FIG. 17. Target as Viewed From Track Muzzle
Before and After Test.



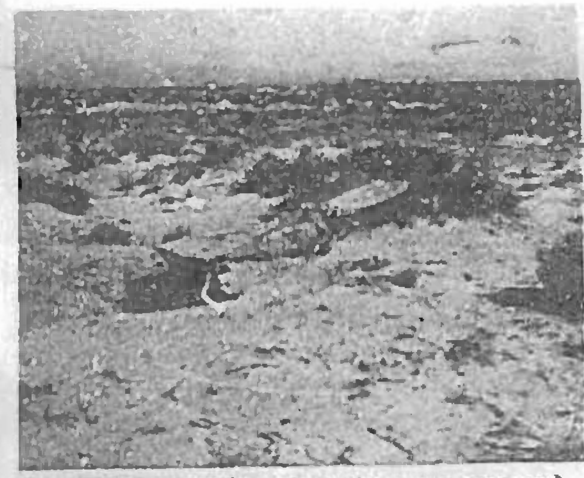
FRAGMENT IDENTIFICATION TABLE

Number	Description
1	Residue of burned propellant
2	Residue of burned propellant
3	Residue of burned propellant
4	Fragment of rear motor closure, approx. 7'x3'
5	Fragment of sled ring, approx. 5.5' long
6	Fragment of motor case, approx. 2.5'x4.5'
7	Fragment of concrete, approx. 300 lb
8	Fragment of concrete, approx. 12 lb
9	Four marks of burned propellant
10	Two marks of burned propellant
11	Fragment of motor case, approx. 4'x6'
12	Fragment of motor case, approx. 4'x4'
13	Residue of burned propellant
14	Residue of burned propellant
15	Residue of burned propellant
16	Fragment of motor insulation, approx. 18"x18"
17	Fragment of motor insulation, approx. 18"x18"
18	Fragment of motor case, approx. 8'x4'
19	Fragment of motor insulation, approx. 18"x18"
20	Fragment of motor insulation, approx. 24"x18"
21	Fragment of concrete, approx. 40 lb
22	Fragment of concrete, approx. 500 lb.
23	Fragment of motor, approx. 2'x4'
24	Line of residue from burned propellant
25	Residue from burned propellant
26	Residue from burned propellant, approx. 5' diam.
27	Fragment of concrete, approx. 150 lb
28	Residue of burned propellant
29	Residue of burned propellant
30	Residue of burned propellant
31	Fragment of concrete, approx. 200 lb
32	Residue of burned propellant, approx. 10' diam.

FIG. 18. Dispersion of Fragments



19,800' N x 1,475' E (2,400' SE of impact point)



22,100' N x 1,200' E (1,260' NE of impact point)

22,000' N x 1,200' E (1,240' NE of impact point)

19,400' N x 900' W (2,500' SW of impact point)

FIG. 19. Montage Showing Large Pieces of Debris.
(See note on page 4, third paragraph.)

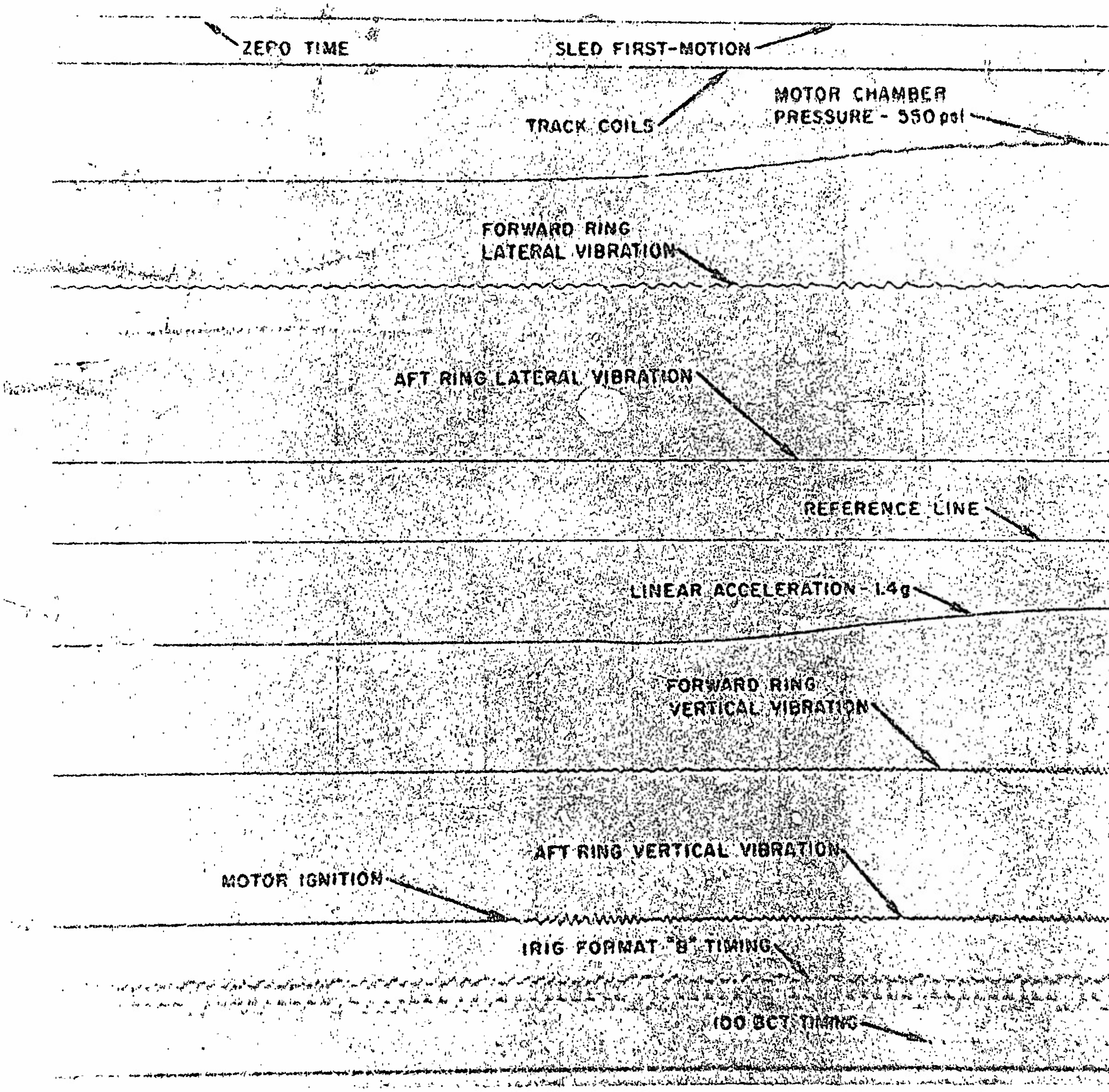
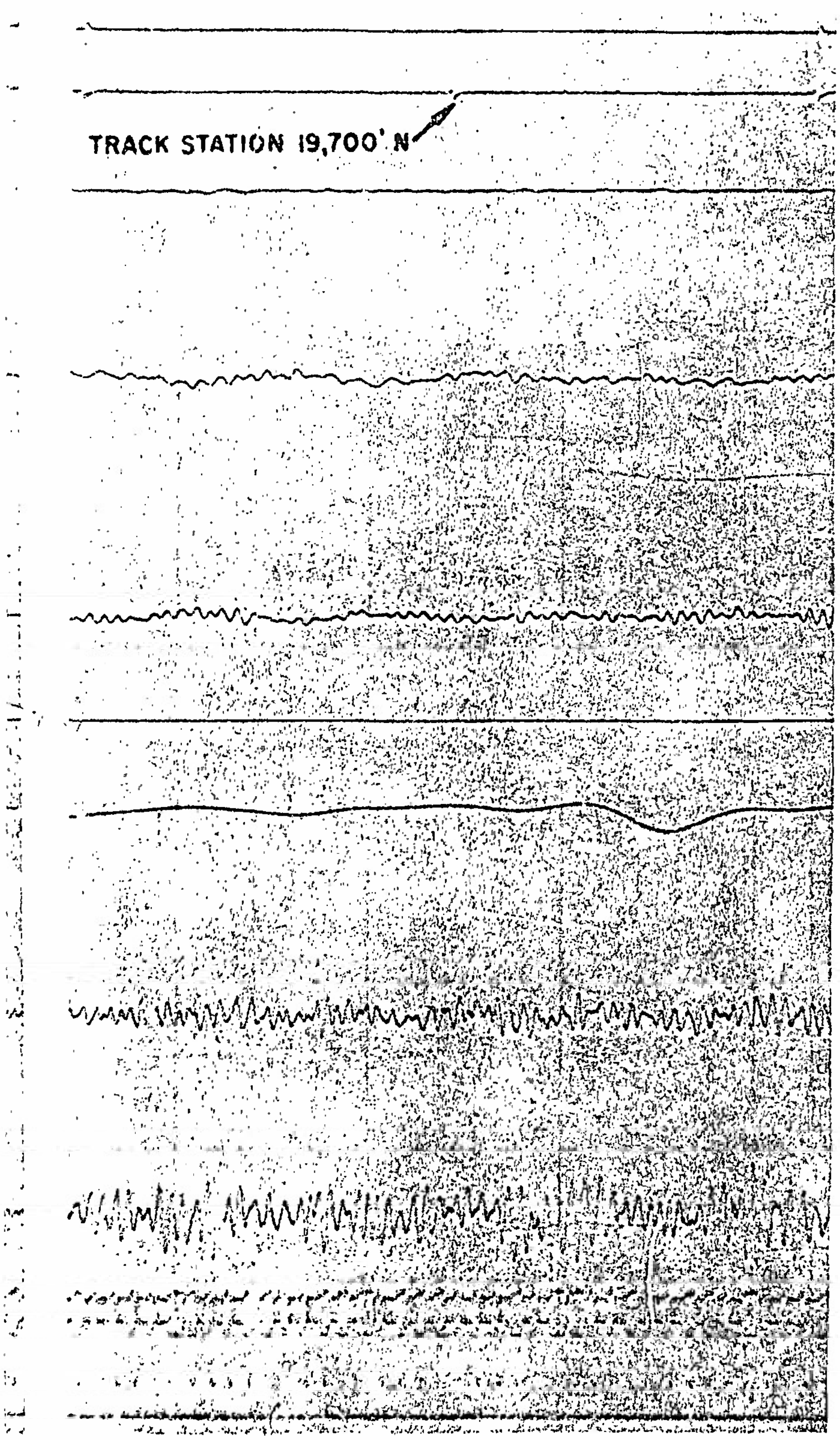
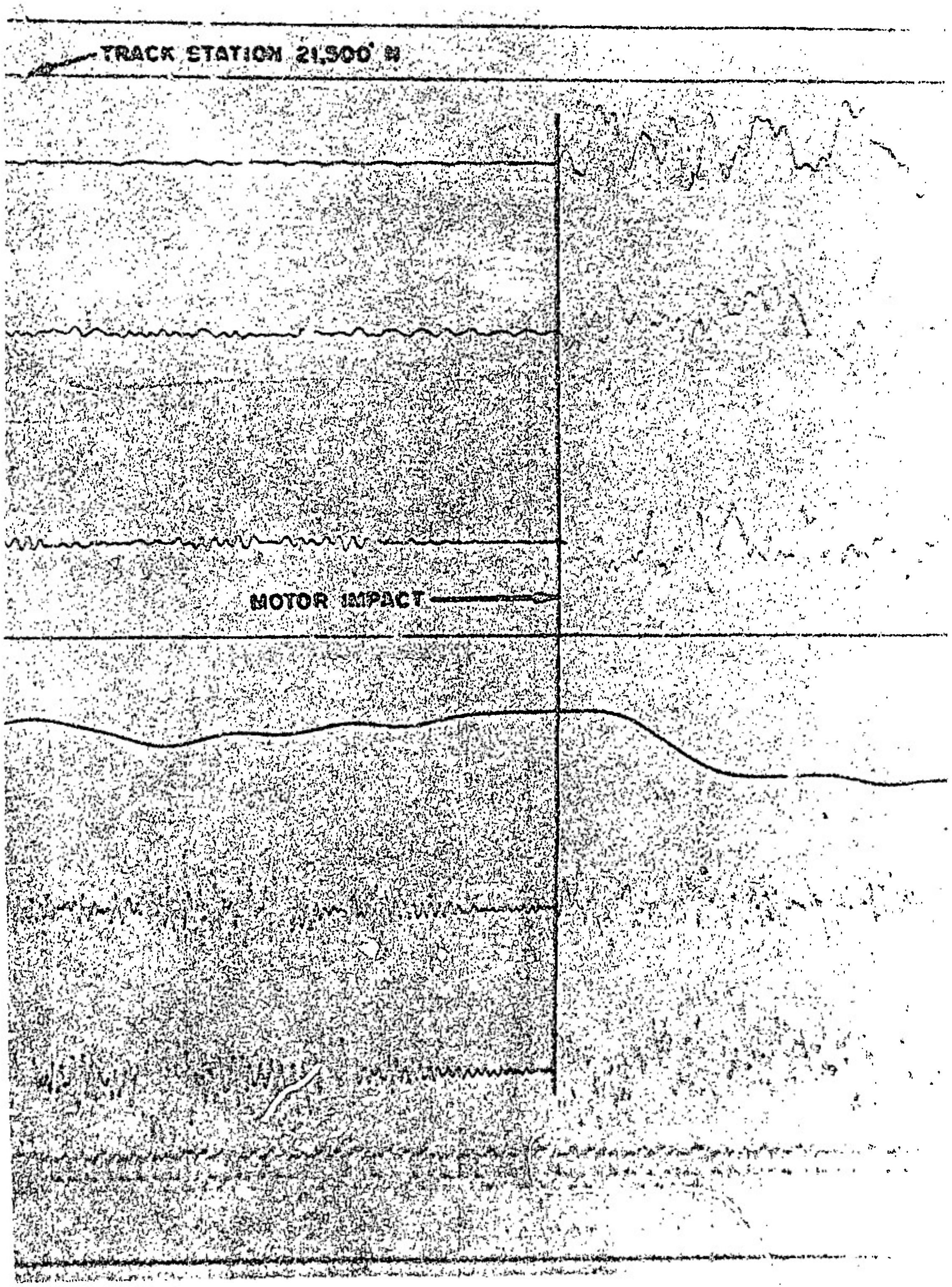

ZERO TIME
SLED FIRST-MOTION
TRACK COILS
MOTOR CHAMBER PRESSURE - 550 psi
FORWARD RING LATERAL VIBRATION
AFT RING LATERAL VIBRATION
REFERENCE LINE
LINEAR ACCELERATION - 1.4g
FORWARD RING VERTICAL VIBRATION
AFT RING VERTICAL VIBRATION
MOTOR IGNITION
IRIG FORMAT "B" TIMING
100 BCT TIMING

FIG.



Sections of Telemetry Record Obtained During Test.



TRACK STATION 21,500 ft
MOTOR IMPACT

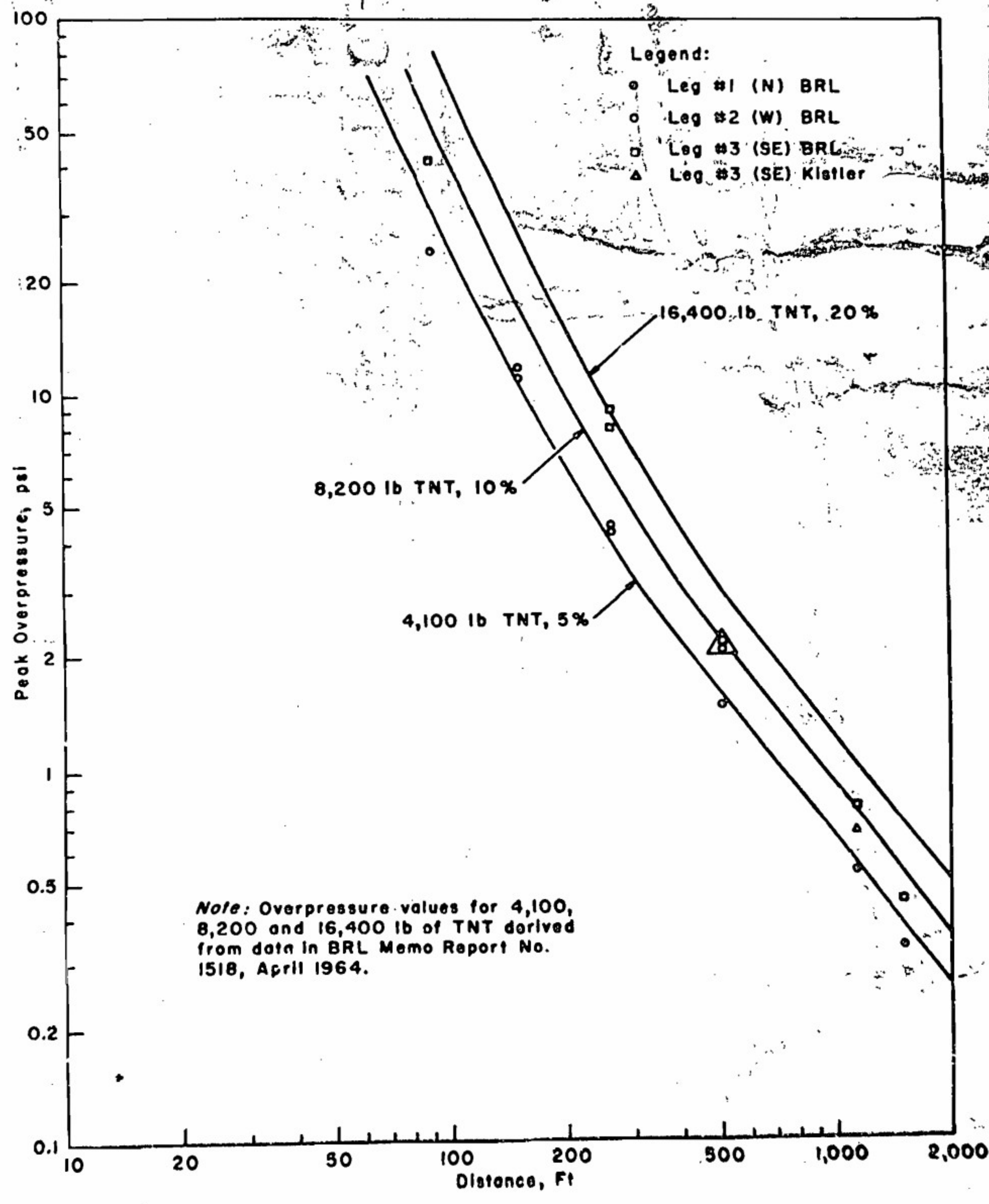


FIG. 21. Graph Showing Overpressure Vs. Distance.

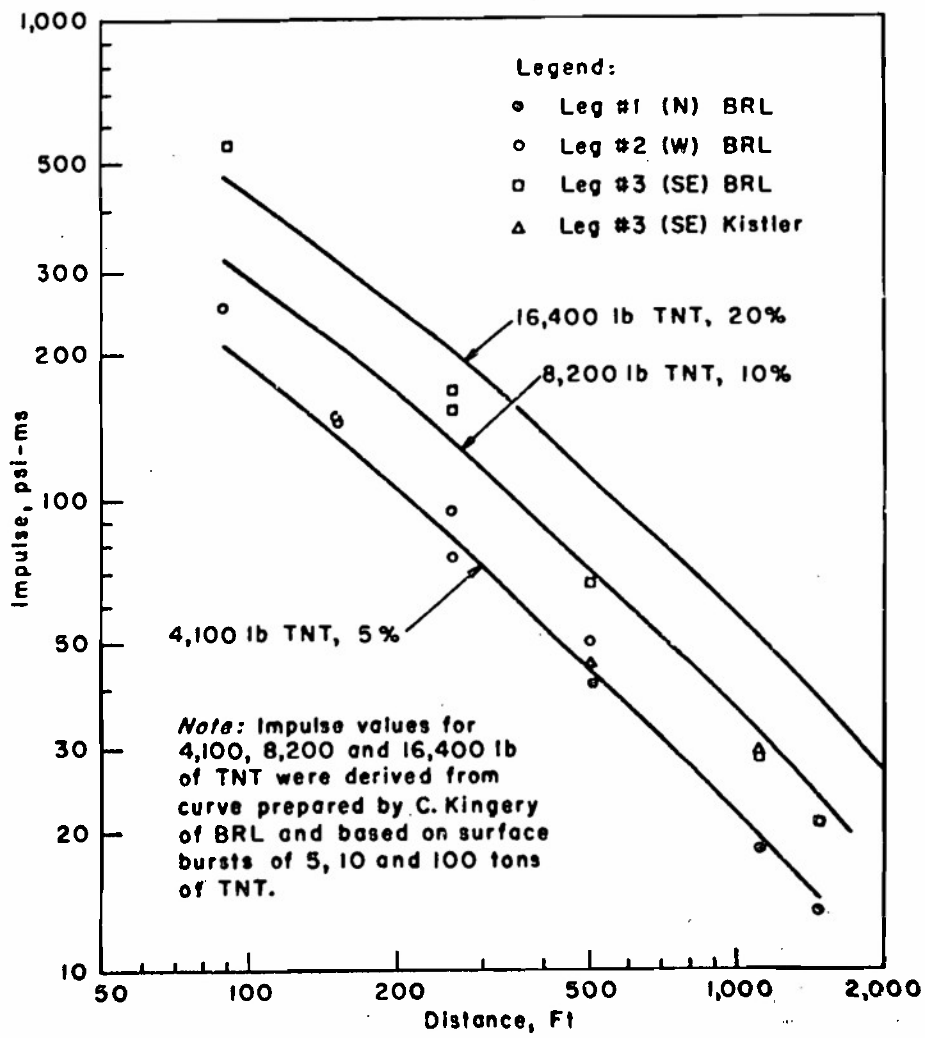


FIG. 22. Graph Showing Impulse Vs. Distance.

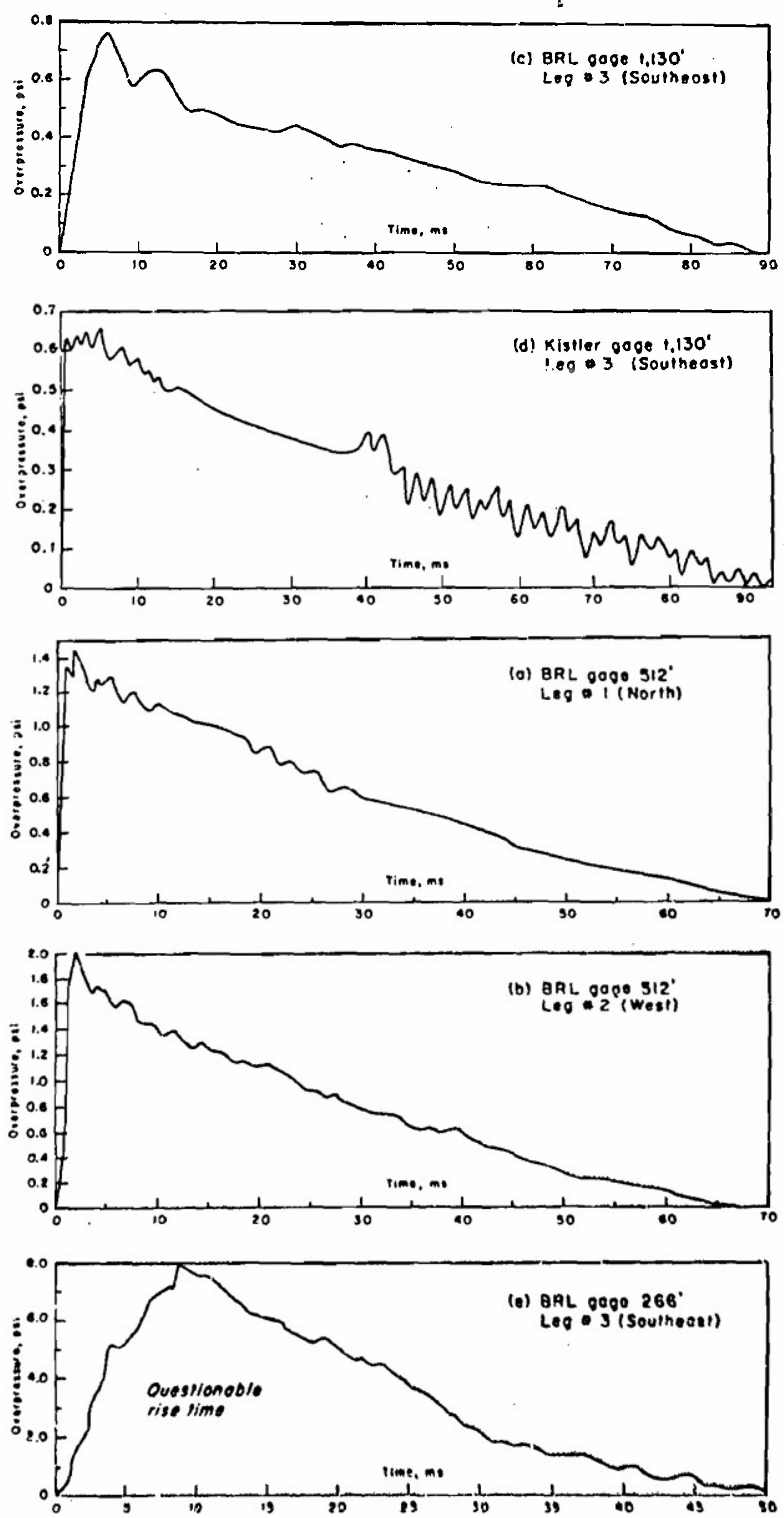


FIG. 23. Typical Blast Gage Records (Note Scale Variation).

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ABSTRACT. At the request of the Air Force Systems Command, a preprototype version of the 624A motor, with a single center segment plus end closures, was impacted into a massive concrete, steel, and earth target at a velocity of 667 fps to determine the haz-

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This report presents a description of the test setup, procedures, results, and conclusions.

TPR 381

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